Characterisation of plasma properties for wall conditioning studies on the TOMAS device

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Wall conditioning, plasma surface interaction, and plasma production studies are of high importance for an effective commissioning and operation of superconducting fusion devices like W7-X, JT-60SA, and ITER. These topics can be investigated in a specialised experimental setup known as the TOroidal MAgnetic System (TOMAS), which has undergone significant upgrades in recent years [1]. The TOMAS experiment is situated at the Forschungszentrum Jülich in Germany and focuses on ion and electron cyclotron (IC/EC) plasmas. The plasma confinement is achieved through a toroidal magnetic field generated by 16 copper coils, reaching values up to 125 mT at the centre. The device has a major radius (R) of 0.78 m, a minor radius (a) of 0.26 m, and a total plasma volume of approximately 1.1 m3. Figure 1 provides a schematic view of the TOMAS device. Both the IC and EC systems can deliver up to 6 kW of power, with the EC frequency set at 2.45 GHz and the IC frequency ranging from 10 to 50 MHz. Additionally, a direct current glow discharge cleaning (GDC) system, utilising a graphite anode with a maximum voltage of 1.5 kV and a current of 6 A, has been installed. Material samples can be exposed to the plasma using a load-lock system equipped with a vertical manipulator. The device is equipped with various plasma diagnostics, and additional measuring tools are currently being incorporated [2]. These include a Langmuir probe system, optical and particle diagnostics.

Recently, a series of experimental campaigns have been conducted, focusing on sample exposure, plasma characterization, and diagnostics commissioning. The first area of investigation involves exposing material samples to TOMAS plasmas to study the efficiency of removing co-deposited boron layers. The samples were subjected to GDC in helium as well as IC wall conditioning plasmas in both helium and hydrogen. Systematic changes were made to the plasma parameters to determine the optimal exposure conditions. The power level of the IC system was varied from 1 to 4 kW, and the electrical connection of the sample holder was modified, including floating potential, grounding to the vessel, and applying a negative voltage bias. Pre- and post-exposure analyses were conducted using heavy ion elastic recoil detection analysis and nuclear reaction analysis [3].

To complement the research on wall conditioning in TOMAS, a characterization of IC, EC, and combined IC/EC plasmas was carried out using a radially adjustable triple Langmuir probe.

Finally, new diagnostic tools have recently been put into operation on the TOMAS device. An update will be provided on the RFEA (Retarding Field Energy Analyzer), which is used to investigate ion fluxes, as well as the optical emission spectrometer applied to scenarios for plasma start-up.

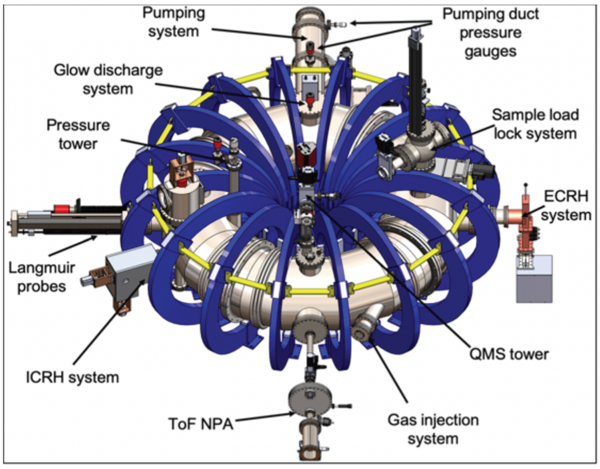

Figure 1. Schematic view of the TOMAS device.

References
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[2] Yu. Kovtun et al., JINST **18** C02034 (2023)
[3] P. Petersson et al., "The influence of plasma parameters and electrical connection on the efficiency of wall conditioning plasmas in TOMAS facility", presented at 19th International Conference on Plasma-Facing Materials and Components for Fusion Applications, Bonn, 22 – 26 May 2023